Vertical electron density profiles from GRACE radio occultation measurements

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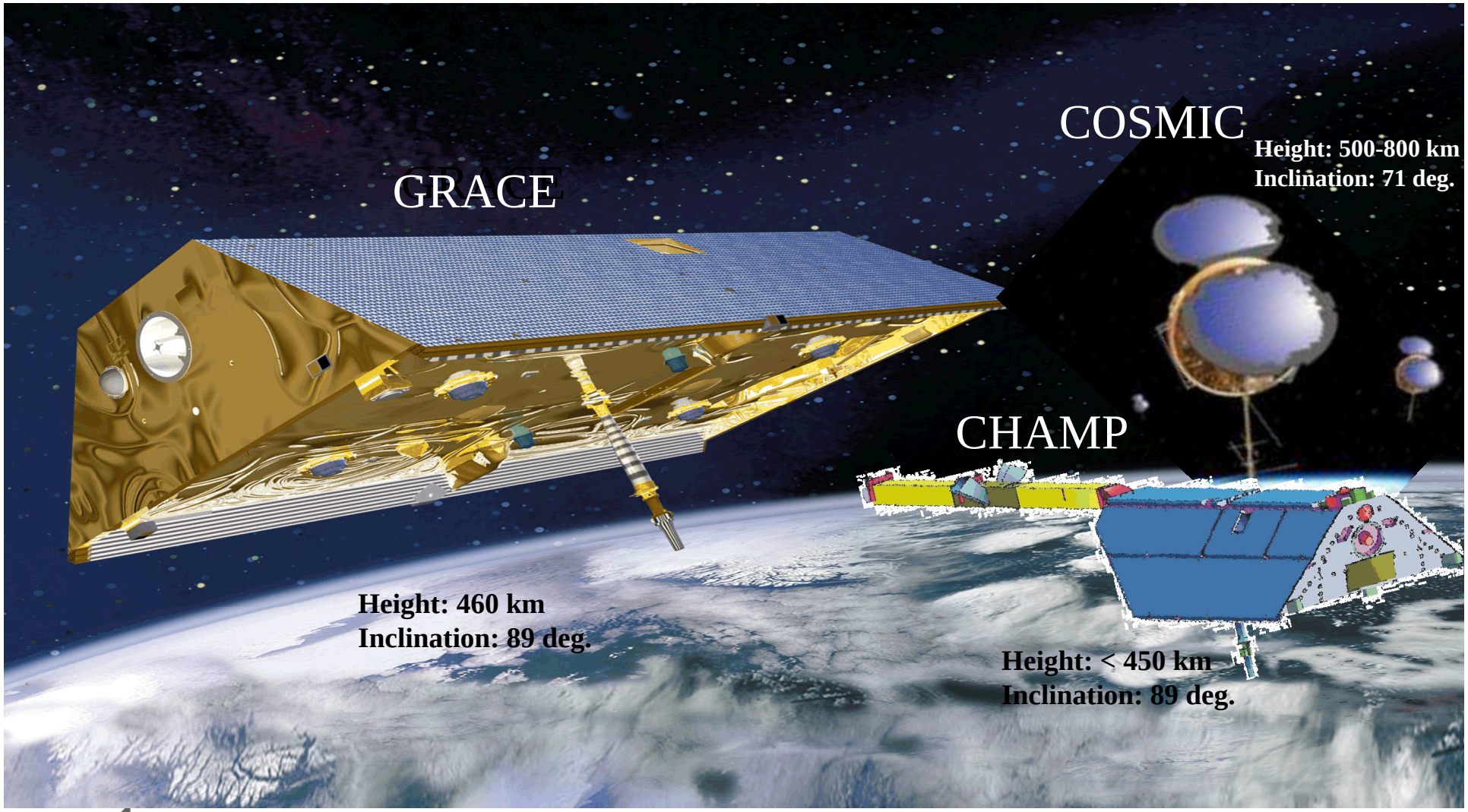
Outline

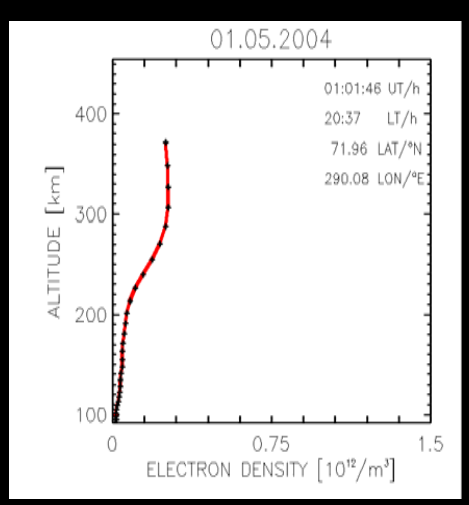
- Introduction
- Ionospheric Radio Occultation measurements
- Data coverage
- Comparative analysis of ionospheric parameters retrieved from GRACE, CHAMP and COSMIC satellites
- Summary and conclusions

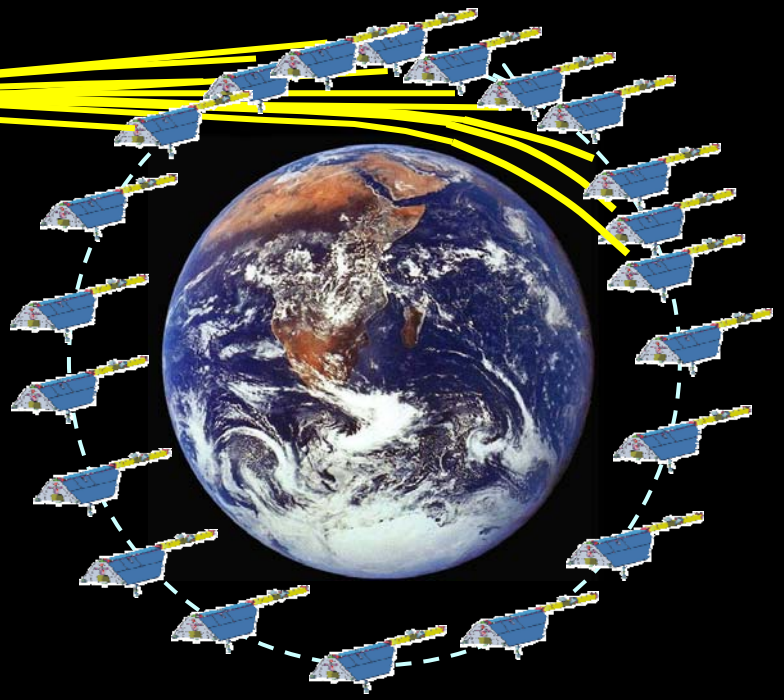
Satellite missions GRACE, CHAMP, COSMIC



GPS sounding of the ionosphere onboard GRACE satellite

GPS Satellite



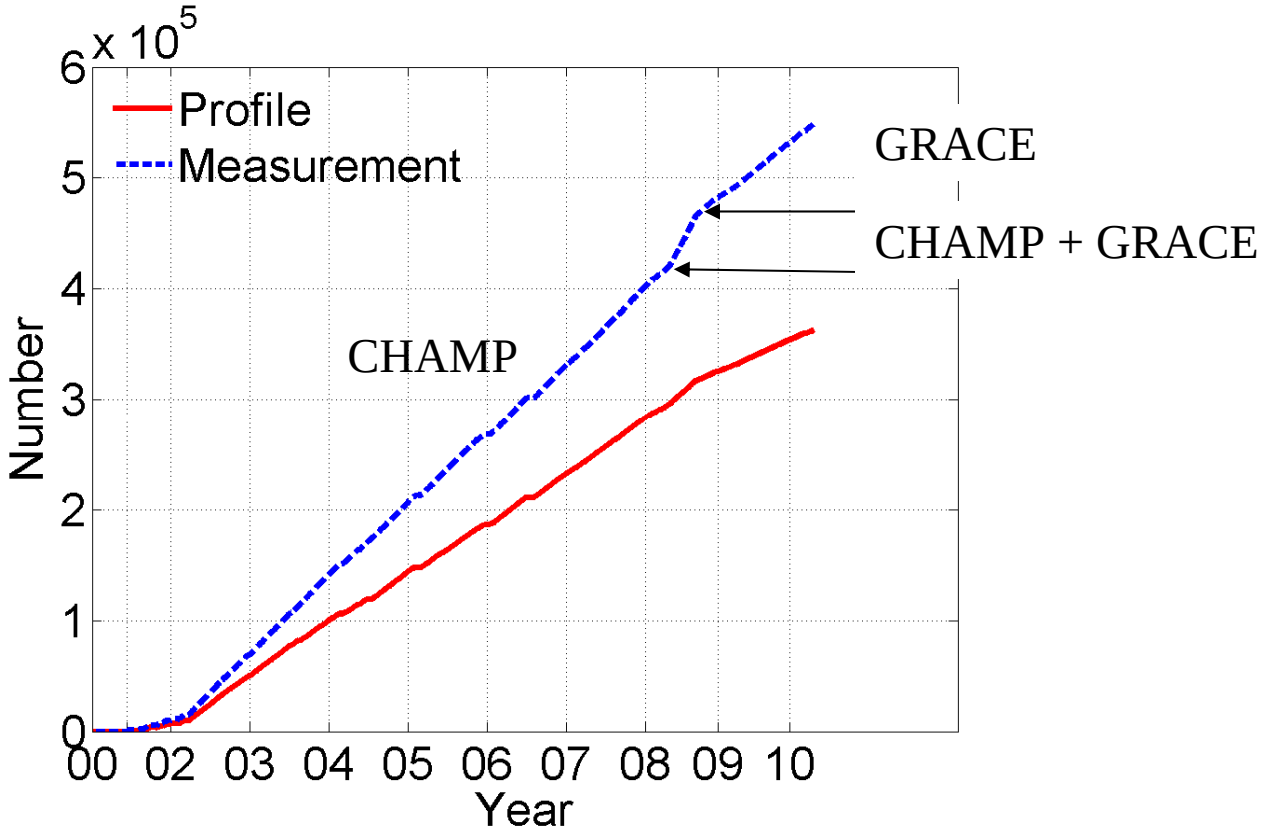


Occultation (1Hz)

GRACE Orbit

GRACE

Ionospheric radio occultation measurements & retrievals



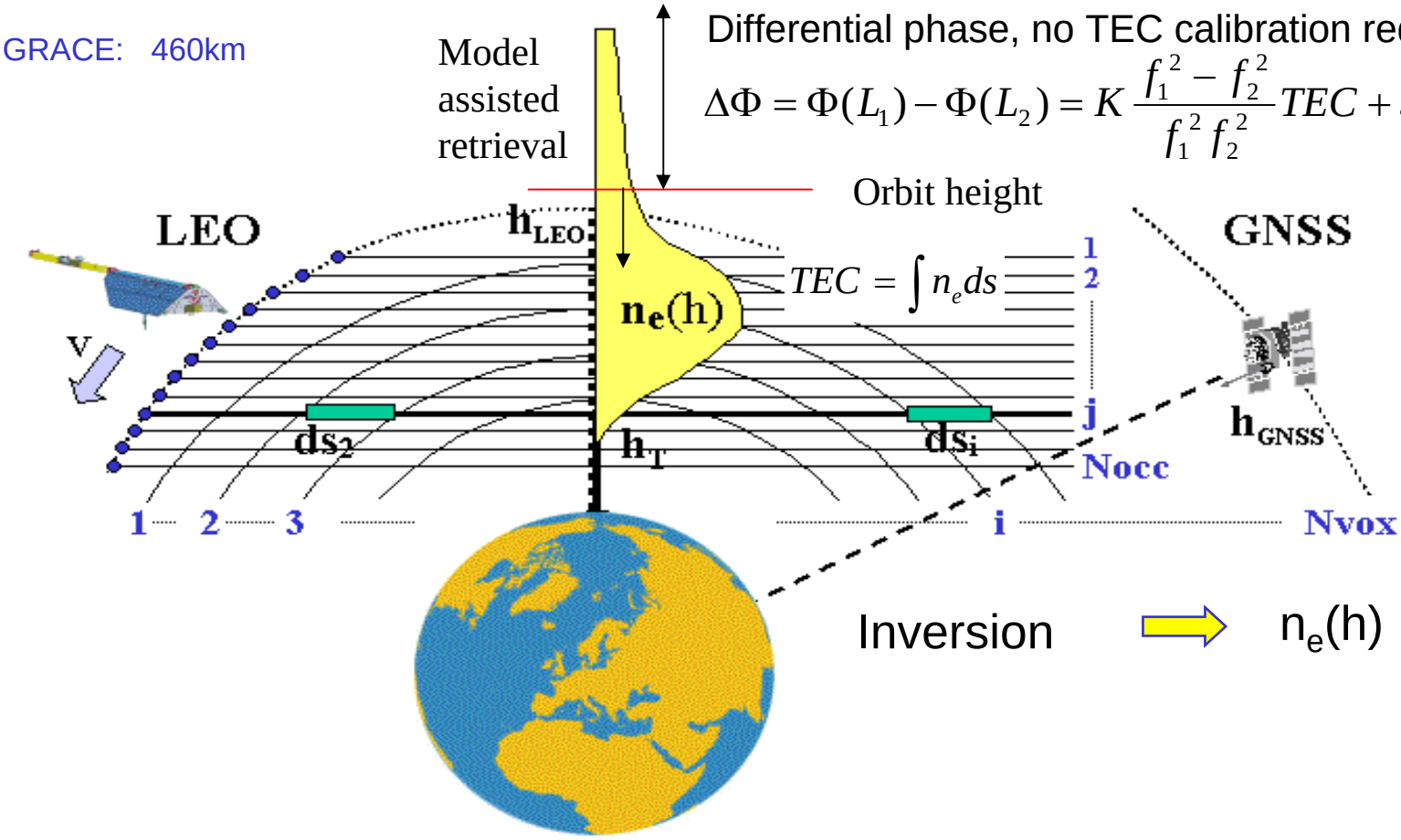
- Continuous IRO measurements and retrieved electron density profiles since April 2000, in total more than 370,000 profiles are obtained so far.
- GRACE contributed with about 60,000 vertical electron density profiles.

Retrieval of electron density profiles

Topside ionosphere/plasmasphere

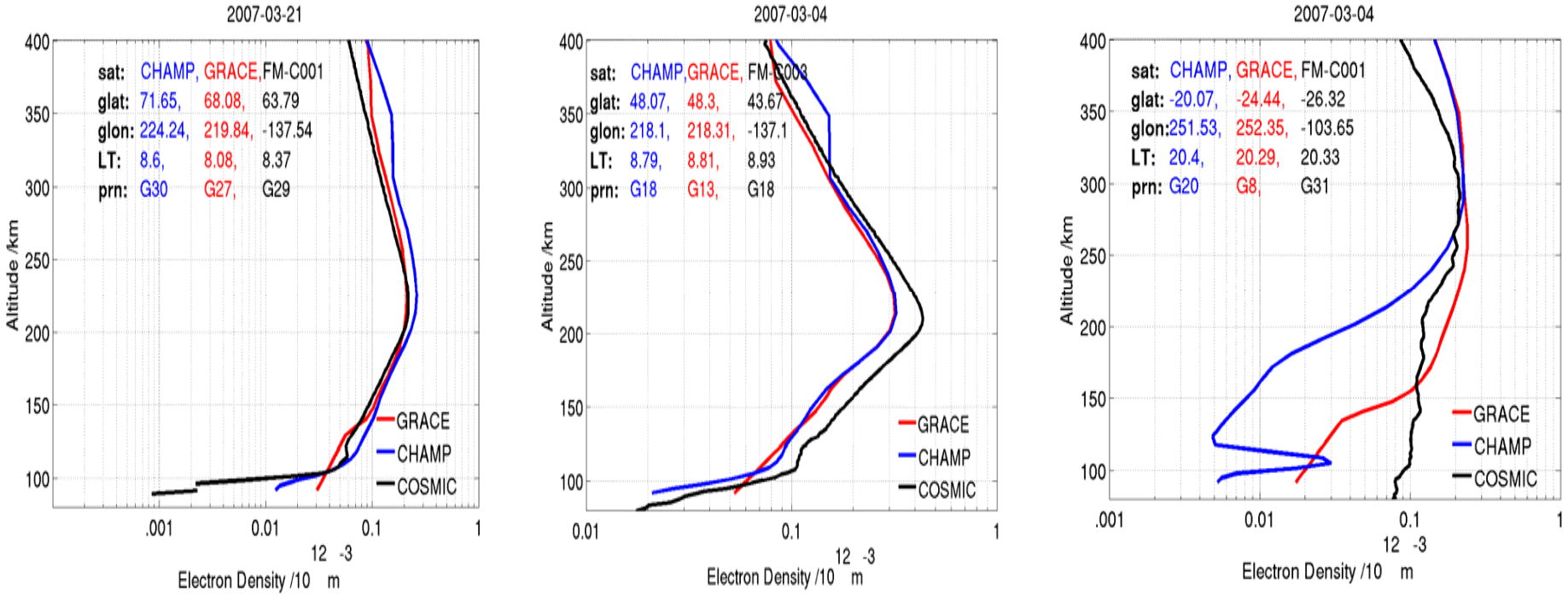
$$n_e \sim \exp(-h / H_S)$$

h_{GRACE}: 460km



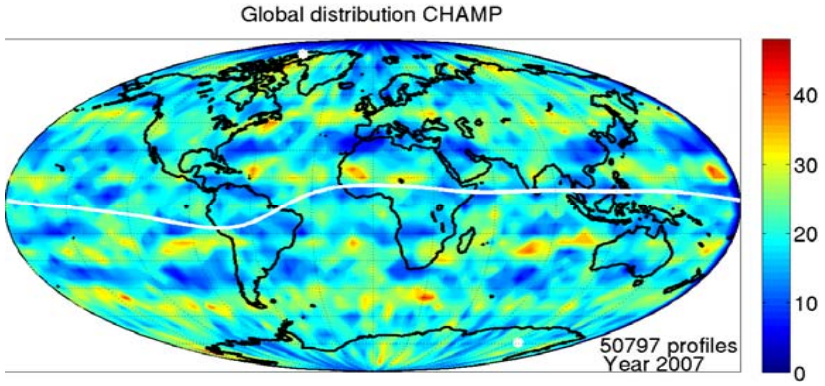
Jakowski, N., A. Wehrenpfennig, S. Heise, Ch. Reigber, and H. Lühr, GPS Radio Occultation Measurements of the Ionosphere on CHAMP: Early Results, Geophys Res Lett, 29, No.10, 95-1, 2002

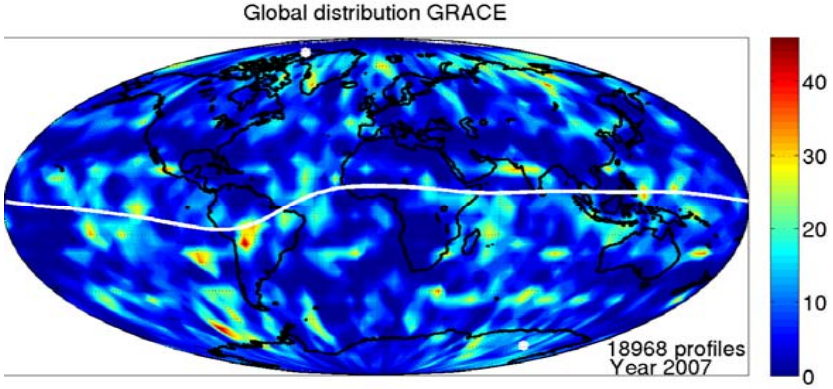
IRO profiles from CHAMP, GRACE and COSMIC



- Triple coincidences of occultations enable comparison of results obtained by different types of retrievals from radio occultation measurements at three satellites
- In general the agreement is fairly good

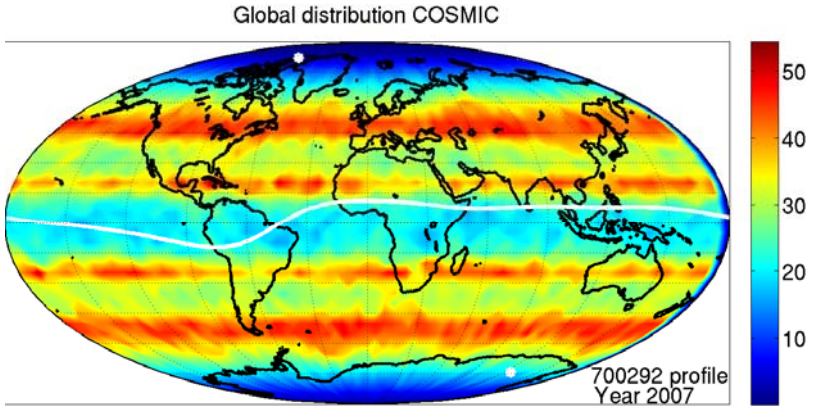
Global IRO data coverage



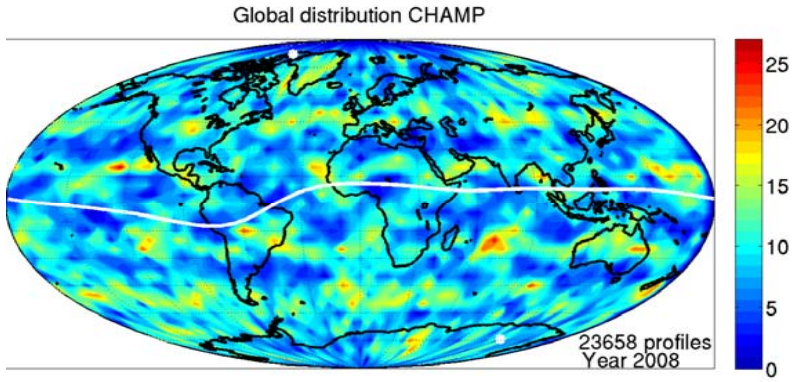


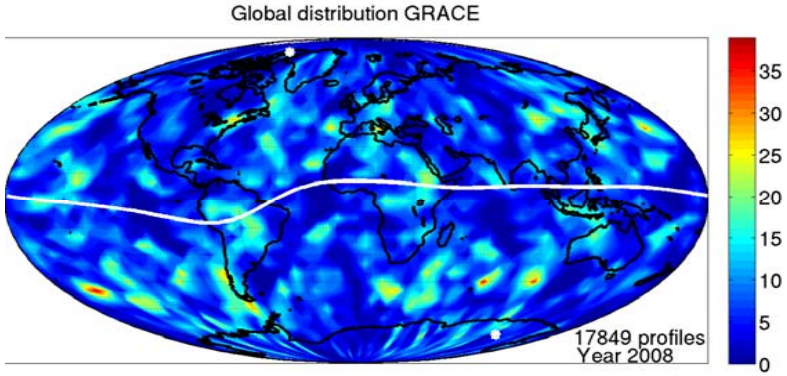
Number of retrieved profiles per 5°x 5° pixel

- Orbit geometry of LEO satellites in relation to GPS orbits causes typical data coverage pattern



Global IRO data coverage





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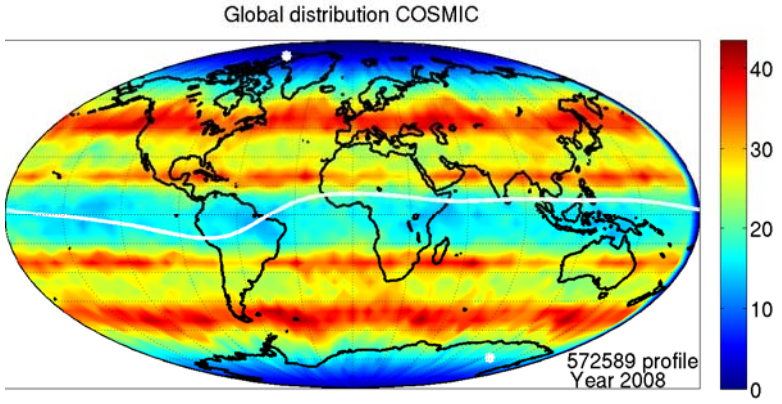
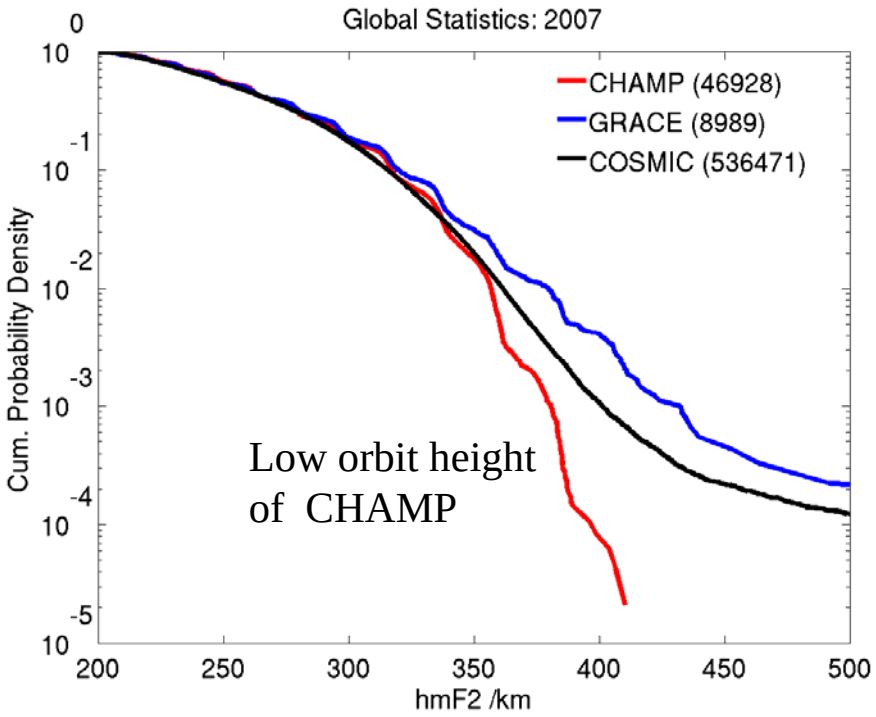
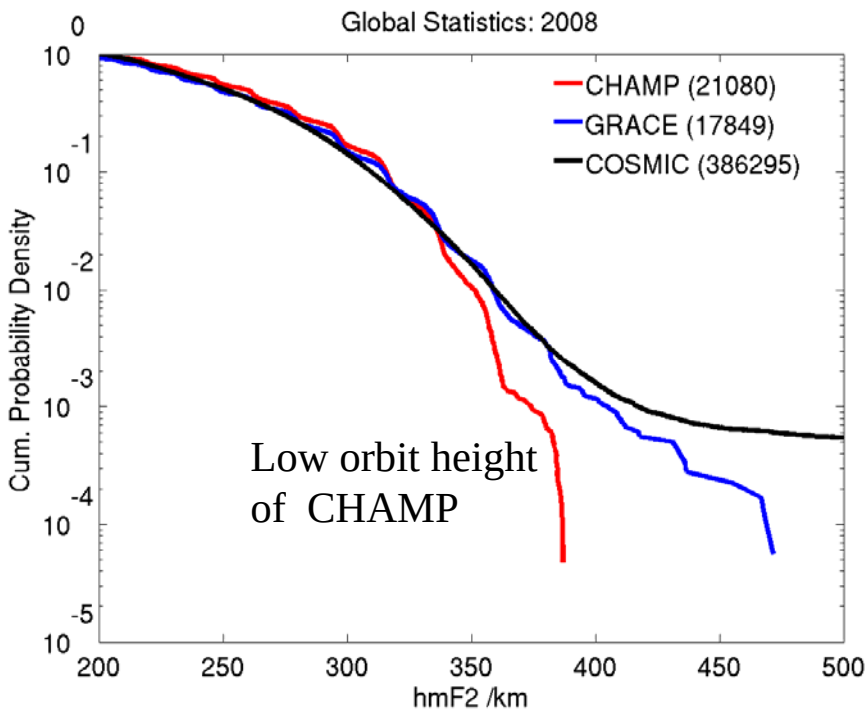


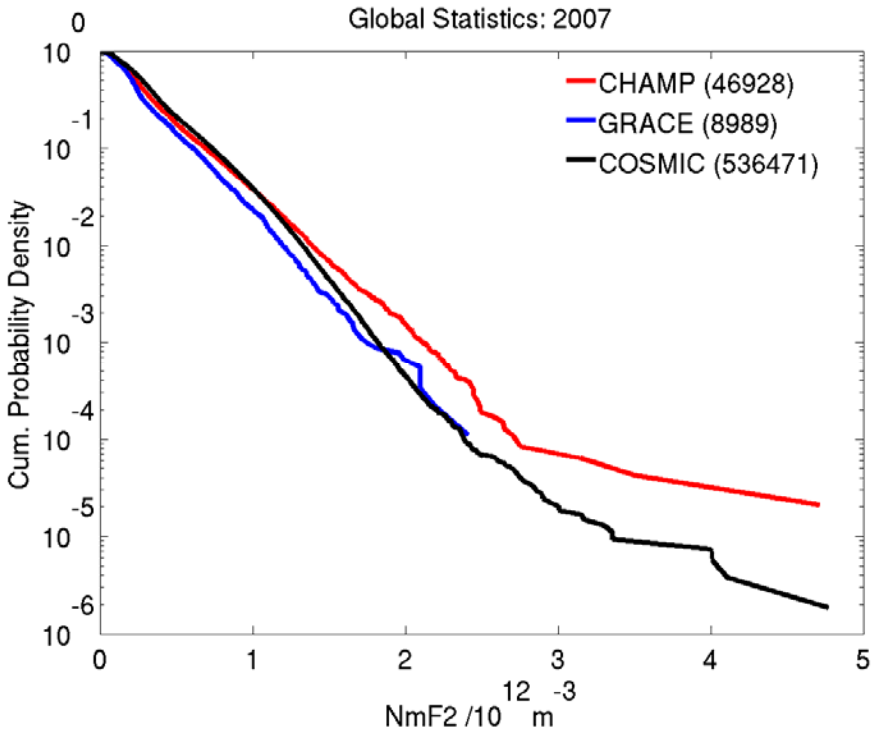
Cumulative statistics of hmF2

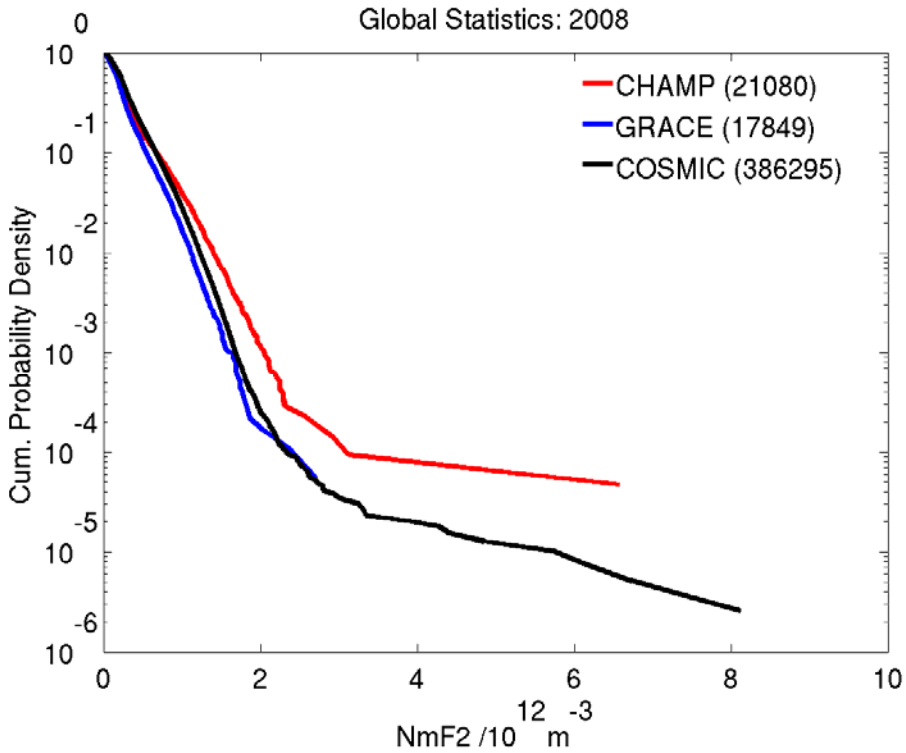




- Differences at greater heights (> 350 km) are due to differences of satellite orbit heights.

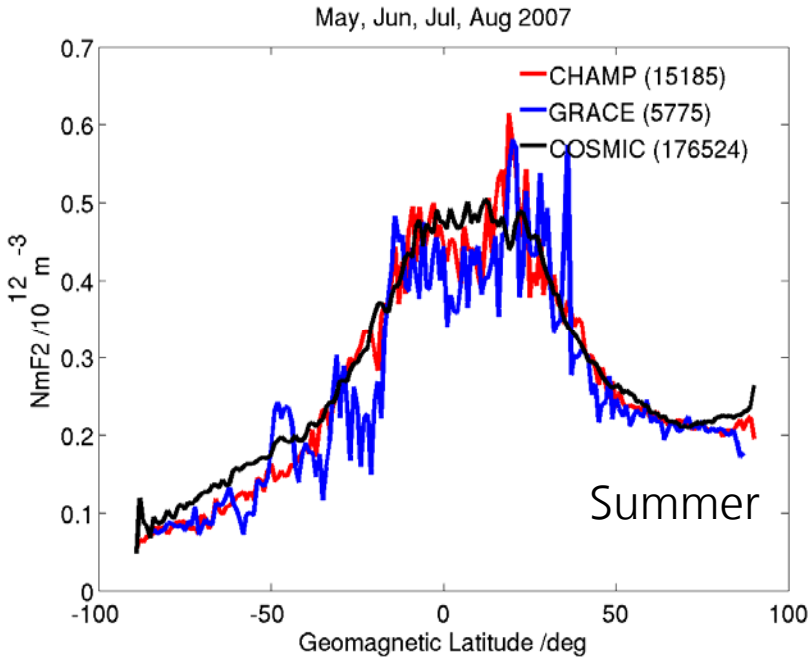
Cumulative statistics of NmF2

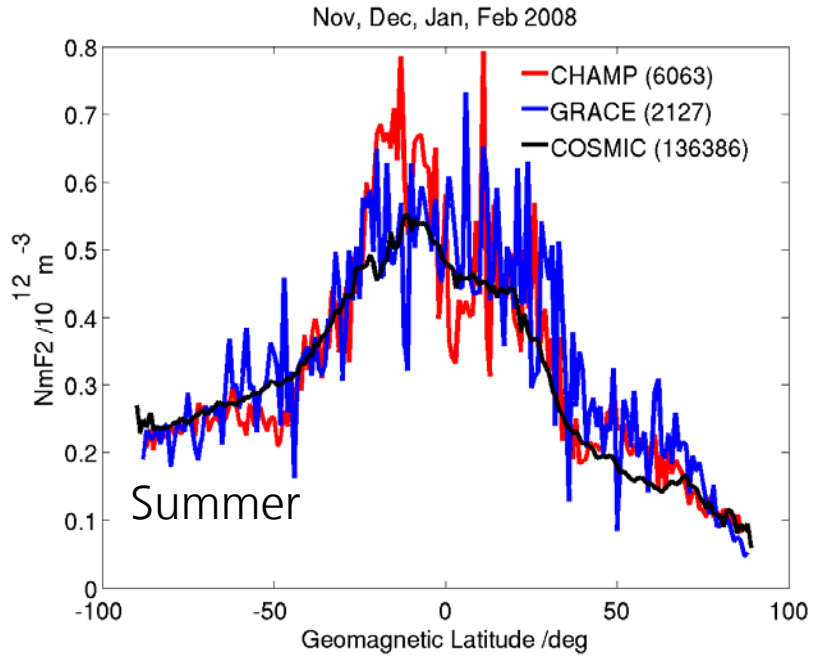




- In regions characterized by high background ionisation CHAMP observes more often higher peak densities than COSMIC and GRACE
- This is probably due to the lower orbit and subsequent impact of the topside model.

Latitudinal dependence of peak electron density

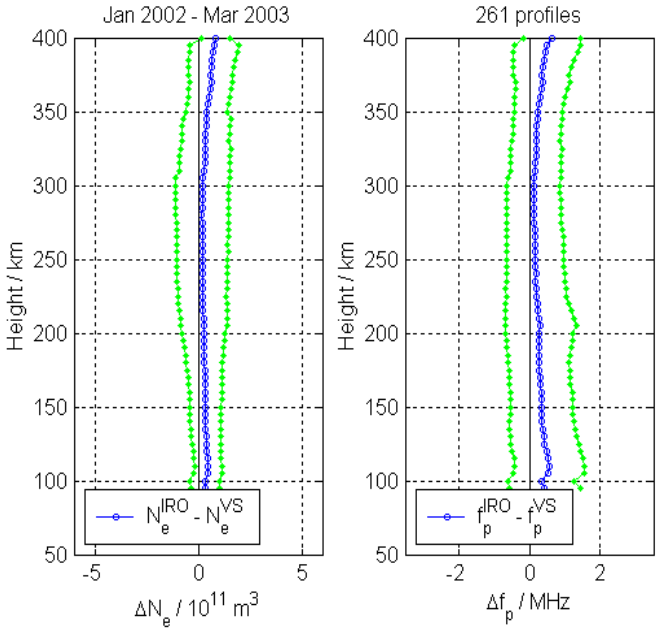




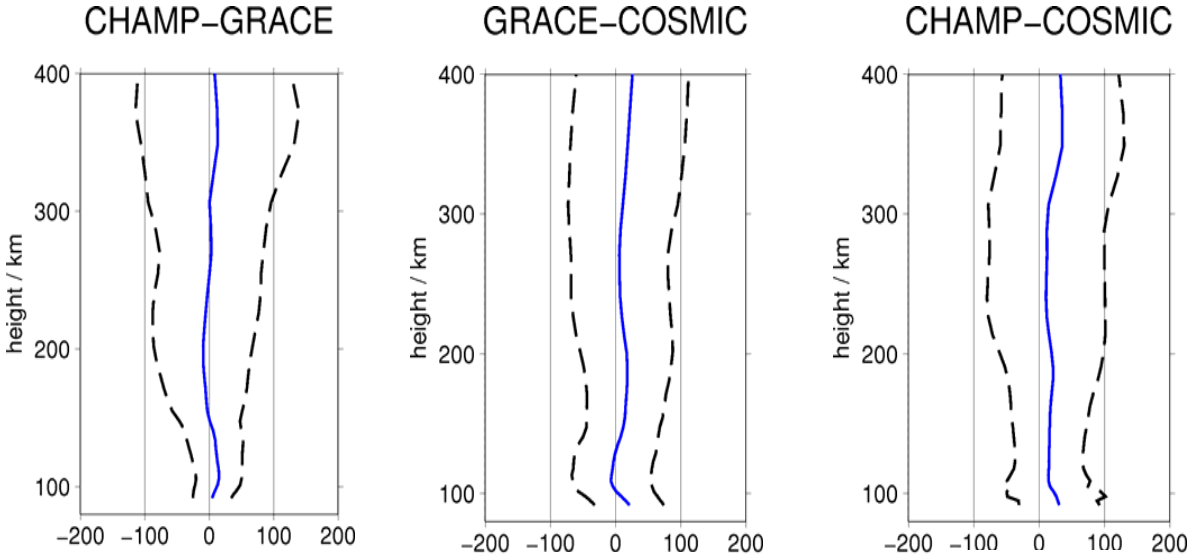
- Meridional distribution of plasma density derived from all three satellites agrees very well,
- Crest is more pronounced at the summer hemisphere
- Clear seasonal difference at high latitudes

Intercomparison between electron density profiles retrieved from different satellites

CHAMP- JR055



Time window: 10 min
Distance: < 8 deg



- Good agreement between electron density profiles derived from different satellites and by different retrieval techniques for 2007 data sets
  - small bias
  - small standard deviation

Jakowski et al., in C. Reigber, H. Lühr, P. Schwintzer, and J. Wickert (Eds.), Earth Observation with CHAMP, Results from Three Years in Orbit, Springer-Verlag Berlin, pp. 447-452, 2005

Summary & Conclusions

- More than 60,000 vertical electron density profiles of the global ionosphere have been retrieved from IRO measurements onboard GRACE since 2007.
- Due to the overlapping of IRO measurements onboard CHAMP and GRACE in 2007/08 the data collection of vertical electron density profiles could be continued without any interruption.
- Comparison of IRO profiles derived from GRACE, CHAMP and Formosat-3 measurements reveal good agreement.
- Basic ionospheric features are well reproduced in data from GRACE.
- Biases and standard deviations agree with CHAMP- ionosonde comparison.
- Validation of IRO data must continue.
- There is an outstanding potential of multisatellite data analysis for ionospheric research and space weather monitoring via close cooperation between GFZ and DLR.

Acknowledgement

The authors are grateful to the international GRACE and CHAMP teams for maintaining the operation and reception of the GRACE satellite over many years. We thank also the Formosat-3/COSMIC team for making available their data products.